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# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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# THE JOURNAL

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# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXIV, No. 7 SEPTEMBER, 1930 WHOLE No. 196

PAGE

**Articles**

Requirements in the Design and Construction of the Large Modern Telescope (with plates X-XX) - - - *J. W. Fecker* 297
The Orbit of 103 Tauri - - - - - - - *S. N. Hill* 305
The Man in the Moon (Radio Talk) - - - *H. R. Kingston* 307
The Eugene Meeting of the A.A.A.S. (with plates XXI, XXII) *W. E. Harper* 313
"The Size of the Universe" (Silberstein). Review by *A. V. Douglas* 322
The Sun (A summary of items) - - - *W. G. Colgrove* 327
Wrinkles in the Art of Telescope Making - - *E. I. Gale* 333

**Review of Publications**

Heaven and Earth: a Modern Astronomy (Oswald Thomas); La Planète Mars (Antoniadi) - - - - - *C. A. Chant* 338

**News and Comments**

News of Canadian and other Astronomical Work - *REDcL* 340

**Notes and Queries**

A Daylight Meteor—The 2,000th Anniversary of Virgil's Birth—Another 6-inch Reflector—The Planet Pluto—An Observatory in the Panama Canal Zone - - - - - - *C.A.C.* 342

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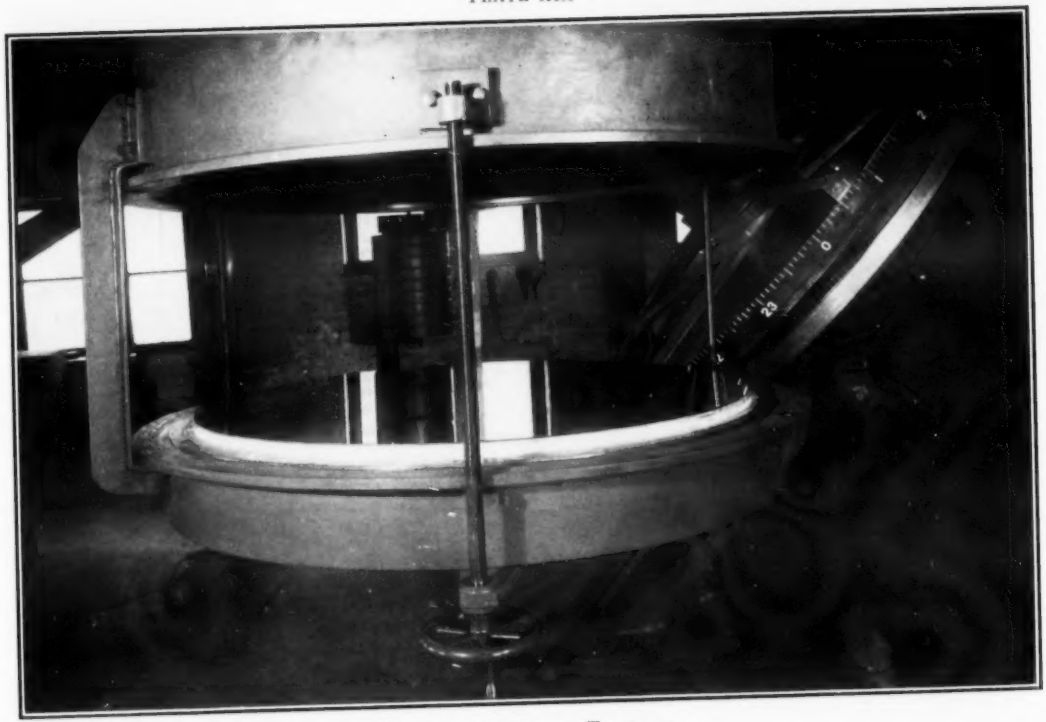
Fig. 11.—The 70-inch Disc of Glass in its mould at the Bureau of Standards.
W. R. Warner, S. W. Stratton, P. H. Bates, A. N. Finn, G. K. Burgess (Director).

*Journal of the Royal Astronomical Society of Canada*, 1930.

*Photo by Underwood and Underwood.*




HARVARD SIXTY-INCH TELESCOPE

Fig. 10. – Sixty-inch Harvard mirror lowered for cleaning or silvering. This form of mounting obviates the necessity of removing the mirror for silvering.

*Journal of the Royal Astronomical Society of Canada*, 1930.

HARVARD SIXTY-INCH TELESCOPE

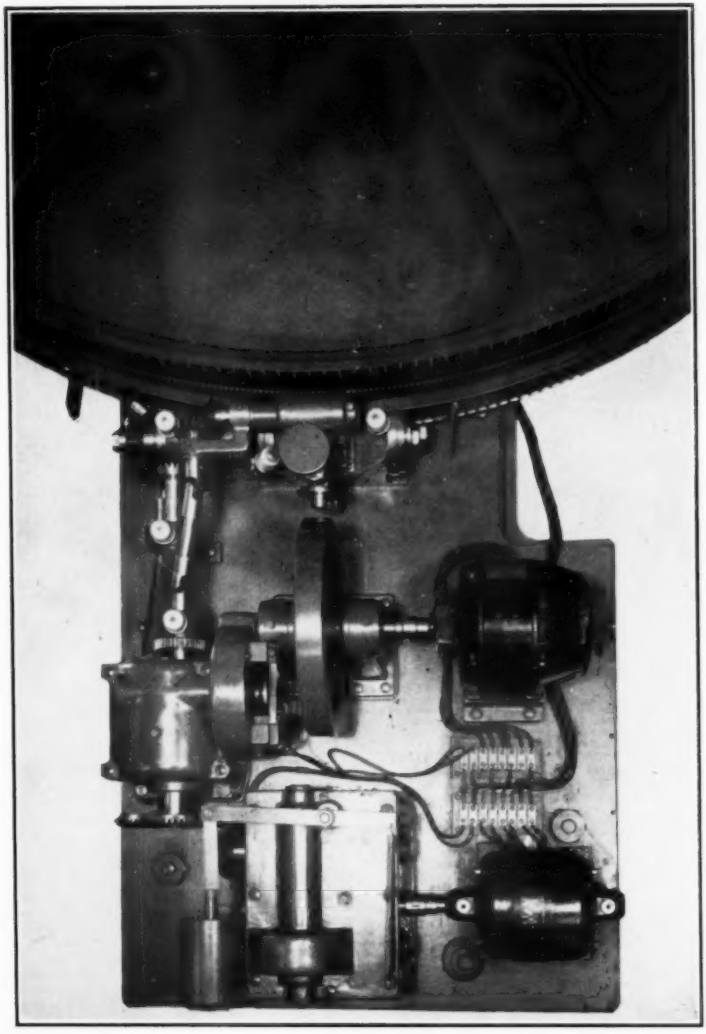
Fig. 9.—View of 60-inch from first floor, showing lower pier head with circles and worm wheel, electric driving unit with cover, lower end of mirror cell, showing screws and brackets for lowering cell for silvering.

*Journal of the Royal Astronomical Society of Canada*, 1930.

GEAR CUTTING MACHINE

Fig. 8.—Showing main drive worm wheel on the gear cutting machine, with gear cutter head and with a divided circle and two microscopes mounted on the worm wheel. In this position the wheel is ready for correction and final lapping.

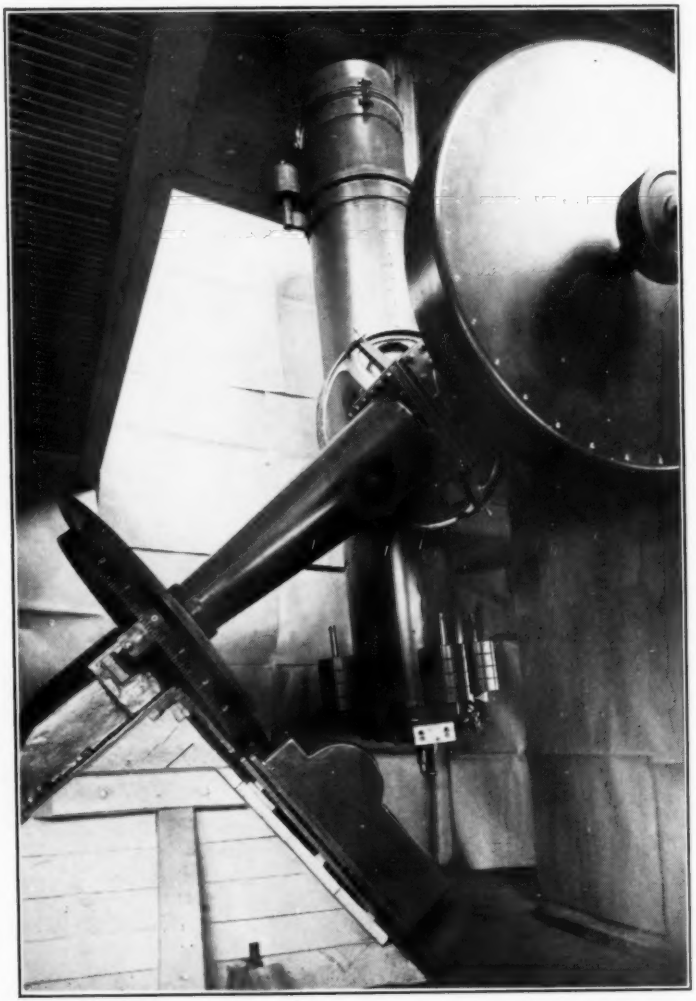
PLATE XVI



ELECTRIC DRIVE UNIT

Fig. 7.—Electric drive unit in right ascension on the sixty-inch telescope, showing quick and slow motion gear box with electric motor operating through differentials to the main worm, and the synchronized electric drive unit operating through the same differential to give sidereal rate in right ascension. Also secondary worm box for driving sidereal circle. Dust-tight cover removed to show entire gearing.

*Journal of the Royal Astronomical Society of Canada*, 1930.

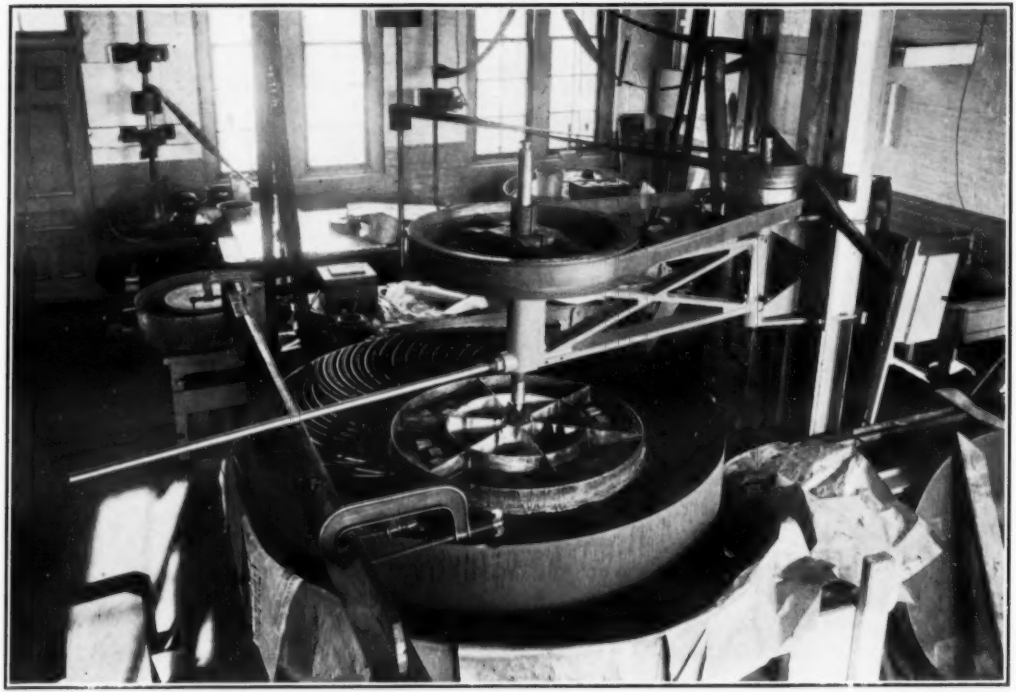


HARVARD TWENTY-FOUR-INCH REFRACTOR

Fig. 6.—General assembly of the twenty-four inch photographic refractor for Harvard College. View from first floor.

*Journal of the Royal Astronomical Society of Canada*, 1930.

PLATE XIV



PERKINS OBSERVATORY DISC

Fig. 5.—Polishing the upper surface of the sixty-nine inch disc for Ohio Wesleyan.

*Journal of the Royal Astronomical Society of Canada*, 1930.

PERKINS OBSERVATORY DISC

Fig. 4.—Sixty-nine inch disc for Perkins Observatory, Ohio Wesleyan University, ground and polished on both sides, ready for the figuring processes.

*Journal of the Royal Astronomical Society of Canada*, 1930.

PLATE XII

HARVARD SIXTY-INCH TELESCOPE

Fig. 3.—General view of the assembly which shows the tube with the Cassegrain secondary in place and cover over the mirror.

PLATE XI

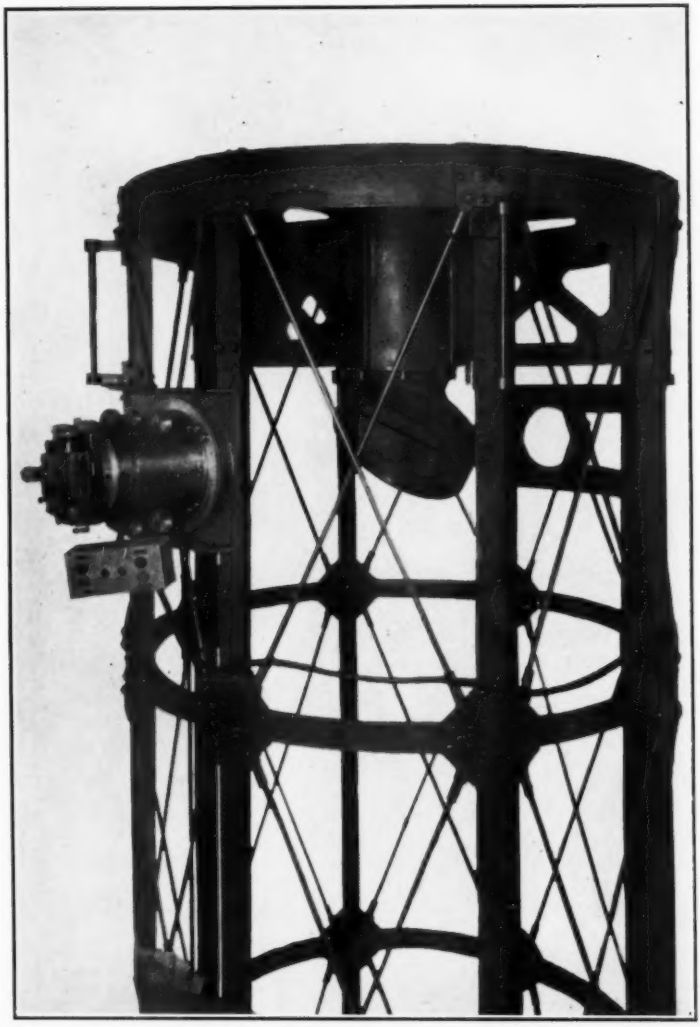
HARVARD SIXTY-INCH TELESCOPE

Fig. 2.—General assembly of the instrument in the plant, taken from the second floor, showing upper end of the polar axis, tube, centerpiece, declination end and gear box.

With the close clearances of the instrument in the building, it was possible to swing the instrument over 55 minutes in right ascension to secure driving tests. The tests showed no trace of periodic or other irregularity in driving.

*Journal of the Royal Astronomical Society of Canada*, 1930.

PLATE X



HARVARD SIXTY-INCH TELESCOPE

Fig. 1.—Upper end of the tube of the sixty-inch Harvard Telescope, showing Newtonian secondary with adapter and double slide plateholder in place, also the push button control box.

*Journal of the Royal Astronomical Society of Canada*, 1930.

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VOL. XXIV, No. 7 SEPTEMBER, 1930 Whole No. 196

# REQUIREMENTS IN THE DESIGN AND CONSTRUCTION OF THE LARGE MODERN TELESCOPE*

With plates X-XX

By J. W. FECKER

The large telescope of the present day is the descendant of a long and distinguished line of the instrument family coming down through the centuries, bearing not only marks of its illustrious predecessors, but holding fast also those principles of construction and design that have tended to bring forth the great telescopes of strength, refinement and dignity common to this generation.

An object embodying as it does both the infinitesimal and the infinite, the interest not only in its uses, but its construction as well, is ever alive for both astronomer and layman.

In the case of the telescope for astronomical use, the purpose for which the instrument is to be used will determine its characteristics both optically and mechanically. A telescope which is to be used mainly for spectrographic work will require a design both optically and mechanically which is radically different from an instrument which is to be used entirely for micrometric work, or from an instrument which is to be used for determining accurately star positions. Both of these designs of instruments will again differ materially from an instrument which is intended to be used

*Revision of address at the Ottawa meeting of the American Astronomical Society, August, 1930.

as a sky patrol and for mapping large areas at a time. In the first case the requirements call for an instrument of extreme light gathering power and stability. The second type calls for an instrument of long focal length, extreme rigidity and not having necessarily extreme light gathering power. The instruments for sky patrol and mapping call for an optical design giving the largest possible field with greatest illumination, requiring a short focus objective of large aperture and correction over a maximum possible field.

The purpose of the instrument having decided the optical design, next in order comes the selection of the glass. From an assortment of roughly over two hundred varieties of one maker alone, each having its own characteristics, a selection is made, and steps taken to ascertain the characteristics or personality traits, may it be said, of that particular *piece* of glass. In other words, what will this selection of glass do under the circumstances it must necessarily pass through, from the first processes until its completion, and what will it do when in use as a finished optical part. The designer must be familiar with the latest developments in glass technology and able to interpret them. He must also be a good mathematician, since optical design is controlled by rigorous mathematical computation. There is no room for either guess work or approximated formulae.

For a mirror the question of optical quality is not present. However, its uniformity as glass, its colour, hardness, annealing quality and the individual characteristics peculiar to the piece of glass selected, are to be borne in mind. The most permanent and most transparent glasses, also those having the lowest co-efficient of expansion, are first choice. The optical design then is concerned not only with these various points, but in addition with the radii, curves, thicknesses, separations and tolerances.

Having determined the constants of the optical system, that is, the diameter of the lenses, material, radii of curvature, thickness, separations and tolerances, the roughing, fine grinding and polishing tools are prepared and the blanks are rough ground, fine ground, polished and then centered. At this stage the optical system is about twenty-five per cent. complete. When the lenses are polished

and centered so that they can be mounted in their cell, it is possible to get a first glimpse of the quality of the optical system. When the computations are properly made, the only errors appearing in the system are spherical and zonal errors due to the action of the polishing tools. These are corrected step by step, the lens or mirror being tested against an optical flat by the autocollimation or Foucault test, and the zonal and spherical errors are reduced to where they are no longer visible.

In smaller lenses the handling of the pieces does not present a serious difficulty. In the larger pieces, however, due to their great weight and cumbersomeness, there are always many risks in the handling of these blanks through the various operations. Every modern engineering aid is used and every precaution taken, yet there is always a certain risk until the last. An example of this may be given in rough grinding the edge of the sixty-nine inch disc for Ohio Wesleyan. It was seventy inches in diameter in the rough, but cleaned up finally to a fraction under sixty-nine inches. Near the edge of this disc were several inclusions of white pot material. As the surface was ground within a half inch of this, considerable strain was relieved and two or three cracks started from this white inclusion running out to the edge. Quick work was necessary with diamond tools to grind out this local strain spot to prevent the cracks from spreading through the disc. Sometimes the same grinding through heavy striae in a reflector disc may start cracks days after all grinding operations have been finished.

In order to avoid the possibility of the roughing and grinding abrasives by any chance getting into the room where the final polishing is done, every precaution is taken to avoid carrying one particle of dust of any description to the polishing room. The processes are carried out on entirely different floors. Also, a man highly skilled in one certain part of the work is not required to do work calling for a lesser degree of skill.

The polishing and hand figuring are done in a constant temperature room adjoining the constant temperature underground testing tunnel, located on the east portion of the building, protected from winter blasts. These two rooms are arranged in such a way

as to make testing possible without transporting the mirror, in fact, testing is done by simply turning the mirror on edge while still on the polishing machine.

Once mounted on the polishing machine, at no stage of the work is the revolution of the disc greater than one in four minutes, and, in the final correction, one revolution in twelve minutes. During rough grinding and polishing, the disc revolves also much more slowly than one would imagine were necessary.

During the tests made between periods of polishing or figuring, there is no atmospheric disturbance whatever in the polishing room or testing tunnel. When the allotted time has elapsed, the test is made by means of the set up at the opposite end of the tunnel. If one were to walk up to the mirror and back, or if one were to so much as press the hand or one finger against the mirror itself, it would require a number of hours for atmosphere and mirror to come to rest before tests could be resumed. For carrying on the tests in the final stages of polishing and hand figuring, all of the equipment is thoroughly checked up and the large optical flats put into service. The flats themselves represent the labour and skill of an expert over a period of a number of years and, for an optical shop, considerable of a financial investment. There is no occasion for elaborate equipment in doing precision optical work. The main object is to save the optician unnecessary labour in the execution of the work. For the rest, it remains with the worker himself to perfect an optical surface, depending upon his experience and ability.

Proceeding with the mechanical parts, these having been previously regarded in a more or less preliminary fashion during the planning of the optical parts, there is, in the main, little change, since the purpose, programme and location of the instrument have already been embodied. It remains to adapt the design to a more extended programme or in such a manner as to take additional attachments conveniently and without disturbing the rigidity, simplicity and smooth operation of the instrument. In regarding the design, some thought must also be given to the prevailing climatic conditions in which the instrument is to be used. An instrument to be used in a warm latitude, a desert where there are frequent

wind and dust storms, makes it necessary that in the design every care be taken to safeguard against the effects of dust and grit getting into the working parts of the instrument. Different oils and greases must necessarily be used in the bearings and gear boxes, which have been made oil-tight. Again, an instrument used in the northern latitudes, which is subject to the great changes of temperature between winter and summer and to severe changes of temperature during the winter months, brings up the overcoming of lubrication, sweating and general upkeep conditions very different from the cases mentioned before; and it requires a radically different design in the working parts to meet these varying conditions. They present another opportunity for astronomer and engineer to work together.

In designing the mechanical parts, the designer must give careful thought to whether certain parts can be more efficiently made and more rigidly made of castings, forgings, or built-up sections, and a careful estimate of costs and probable effects in operation must be made frequently in large parts before an intelligent design can be arrived at. There comes the question of selection of the metals to go into the various parts; whether they will be so shaped as to go through the foundry without impediment; whether they can be machined without undue expense and delay, and without the risk of injury to accurately finished contacting metal surfaces. Improvements in metallurgy are taken advantage of wherever possible; the latest bronze and aluminum alloys are used both for strength and wear. Driving units are non-rusting. Each unit is harmoniously interrelated with other units, and part with part. Each part is tested during the processes of manufacture.

The gears, constituting as they do, with the exception of the optics, the most vital part of the instrument, are carefully worked, lapped and tested finally by optical means until no trace of error remains. It is certain then that the finished instrument will present no periodic error. The allowable tolerance in the worm and worm gear of the sixty-inch Harvard telescope is only one forty-thousandth of an inch.

The axes and tube are then computed for minimum deflection. In designing the optical system through calculation, the maximum

misalignment which can be tolerated without affecting the image is determined. This is usually of the nature of five or ten seconds of arc, but may be less, depending on the type of instrument. The tube is designed to have a maximum deflection not to exceed eighty per cent. of the tolerance. Actually in the tube of the sixty-inch Harvard reflector, this tolerance is ninety-six ten thousandths of an inch in a length of nineteen feet four inches. This small deflection is maintained by the use of heat-treated duralumin tees, angles and tie rods, also duralumin in all parts of the support mechanism.

Axes sufficiently heavy to carry the weight of the optical parts, to which is added the weight of the driving worm wheels and circles, declination sleeve, bearings and worm wheel housing, must of necessity have great static rigidity and stability, and at the same time be moved with uniform ease and without stress or surge. Self aligning ball bearings are used in order to allow movement of the upper or lower end of the axes, thus placing the polar axis exactly parallel with the earth's axis. These bearings are enclosed in oil-tight and dust-tight housings. Hence there is practically no wear over an indefinite period of time.

The driving mechanism may be either by properly synchronized electric motor, or by a pendulum-regulated weight-driven clock, either drive operating through a final worm driving a worm wheel held fast to the polar axis. In the larger telescopes the worm wheel is usually between seven and nine feet or more in diameter and has 720 teeth cut in its bronze rim. The driving shafts, gears, worms and worm wheel must be free from any errors of eccentricity or spacing of the teeth. Where there are several gears and shafts in the clock and worm drive, there is a possibility of producing a period driving error common in some of the earlier telescopes.

In large photographic telescopes, in the Cassegrain combination, equivalent focal lengths as long as 100 feet are frequently employed, and a drift of the star image from the intersection of the crosswire of as much as one thousandth of an inch can readily be detected. Figuring back then, one one-thousandth of an inch deviation in one hundred feet radius is produced by one twenty-five thousandth of

an inch error at a radius of four feet. This is, therefore, the maximum error that can be tolerated in a worm wheel eight feet in diameter. The maximum allowable error in driving, when measured at the one hundred foot focus, does not exceed one-thousandth of an inch. This error must represent the sum of all possible errors in the entire driving mechanism.

To move with precision a mass weighing in the neighbourhood of twenty tons, so as exactly to bisect a star image with a cross-wire of spider silk only about one thousandth of an inch in diameter, calls for an exact balance of all forces and parts in all positions. Any departure would mean that the image could not be moved the desired fraction of a thousandth of an inch without moving it too much or too little. Not only must every necessary step be taken to achieve such an accuracy, but the accuracy must be maintained indefinitely. As far as possible the effects of temperature changes and of deteriorating agents must be eliminated. The instrument must require the least possible amount of handling and labour in its care and upkeep. Gear drives are made to operate in oil baths within oil-proof and dust-proof cases, and the entire assembly of a drive unit is located under a dust-tight cover which can readily be removed if necessary.

Each size of instrument and design must be carefully worked out and all forces, loads, deflections and weights computed with exactitude. To merely take a design of known size and characteristics and to multiply everything by two to make an instrument twice as large, is sure to lead to failure as stresses and deflections increase in some cases as the square and in others as the cube of the increase of aperture. This is, of course, self evident, yet can bear repetition at this point, for we all know that standards of accuracy and wear multiply with increased sizes.

Because the observer's work is done the greater portion of the time in the dark, the simplest means of operating controls have been devised. Electrical controls are used wherever possible by means of a light, portable switchbox with four or six push buttons, on a six-volt circuit, operating relays and dynamic breaking controllers for the motors, the four-button type giving slow motions, forward or reverse, in right ascension and declination, the two extra

buttons giving quick motions. The motions are all electrically interlocked so that two speeds cannot be engaged at once. The wiring is led by means of cables from the observing station, through the hollow axes and to the main switchboard, generally on the observing wall. This switchboard, however, is frequently quite complex, for, in addition to the telescope motions and electrically operated clutches, many wires are brought to the observing point for such accessories as spectrographs, micrometers, guiding eyepieces with illuminated crosswires, and so on.

The many accessories, such as spectrographs of various types and sizes, interferometers, photometers, plateholders and micrometers, not to mention observing platforms and domes, each involves a separate set of problems which must be intimately known to the designer and carefully studied in order to arrive at a successful and artistic design. Each new instrument designed as it is to fit, must be successful the first time and within the tolerances allowed.

Telescope building is at once an exact science and a fine art. While resting in the activity of telescope making, we grow naturally in the knowledge and expression of its art. The successful growth, development, design and building of telescopes has been made possible only through the complete and harmonious co-operation of astronomer and instrument designer, and with this continued co-operation, effectiveness, power and efficiency of astronomical instruments will continue to increase until eventually we will be limited only by atmospheric conditions on this earth.

Pittsburgh, Pa.

# THE ORBIT OF 103 TAURI

By S. N. Hill

The star mentioned above, 1900 $\alpha$ $5^h$ $02.0^m$, $\delta = +24°08'$, visual magnitude 5.50 and type B3, was announced as a spectroscopic binary by Adams, Joy and Sanford,[1] with a range of –26 to +50 km. from 18 plates. Three observations of the star made at the Yerkes Observatory were published by Struve.[2] A number of spectra of this star were secured during the investigation of B-type stars at Victoria. The second and third plates showed a range from –11.9 to +60.9 km., and further spectra were obtained with a view of determining the orbit.

The spectra were secured with the single prism spectrograph whose dispersion at $H\gamma$ is 29 Angstroms per millimetre. On the average 8 lines were measured on each plate of this rather diffuse line star.

From Victoria observations, the writer obtained a period of 58.4 days which was communicated to Dr. Sanford of Mt. Wilson, who very kindly furnished the velocities of 59 observations and suggested that the Mt. Wilson and Victoria observations be combined in a single least-squares solution. From the first two observations of Mt. Wilson, taken about eleven years prior to the first Victoria, the period was corrected to 58.31 days, which was considered definite.

The fifty-nine Mt. Wilson and thirty-six Victoria observations were combined in one least-squares solution, which gave the following final elements:

$P = 58.31$ days
$e = 0.189 \pm 0.017$
$K = 36.73 \pm 0.66$ km.
$\gamma = +16.22 \pm 0.48$ km.
$\omega = 273°.88 \pm 5°.31$
$T = 2424221.266 \pm 0.780$ days
Mass function 0.28 $\odot$
$a \sin i$ 28,900,000 km.

The Yerkes observations were not included in the solution for

[1] Pub. A.S.P. 36, 137, 1924.

[2] Ap. J. 64, 12, 1926.

the sake of homogeneity; however, they are shown on the graph, Fig. I following.

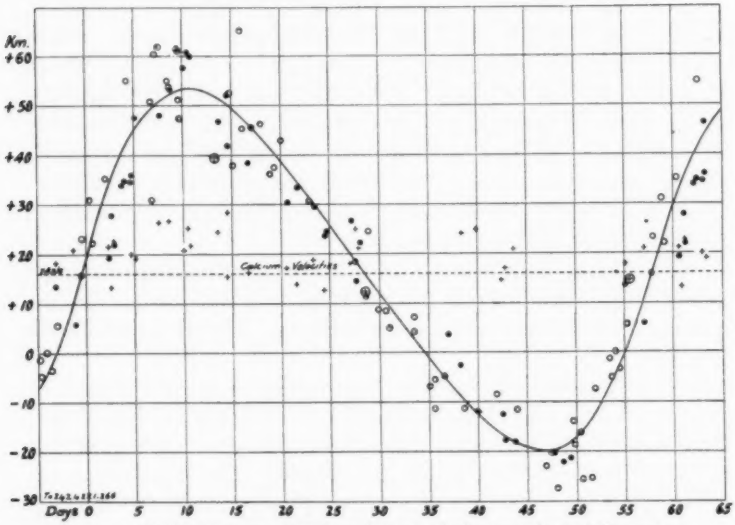



*Fig. I.—Velocity Curve of 103 Tauri, (H.D. 32990) showing individual observations.*
*Mt. Wilson ○ Yerkes ⊕ Victoria ●*
*Calcium Velocities +*

The mean calcium velocity is $+20.1 \pm 0.6$ km./sec., and of this $+11.6$ km./sec. can be attributed to solar motion. This leaves a residual of $+8.5$ km./sec., which must be due to the peculiar motion of the calcium cloud, since the effect of "galactic rotation" in this position of the sky is very small.

On averaging the residuals separately for each Observatory, a mean residual difference, (Mt. Wilson minus Victoria), of $+0.2$ km./sec. was obtained. From this it will be seen that there is very little if any systematic difference between the two observatories in the measure of this B-type star. The probable error of a plate is $\pm 4.46$ km. per second.

A more detailed account of this binary, which is now with the printer, will appear as a Publication, Vol. IV, No. 16, of the Victoria Observatory.

Dominion Astrophysical Observatory,
Victoria, B.C., May 19th, 1930.

# THE MAN IN THE MOON

H. R. KINGSTON

A Radio Talk over CJGC, November 14th, 1929

Throughout all the ages men have been interested in the moon. The people in olden times, living much more out-of-doors than we do to-day, and not being troubled by artificial lights, observed the moon very carefully and knew much more about its motion among the stars than most of us do. Many people to-day are not familiar with the fact that the moon actually moves around the earth from west to east, making the complete circuit in 27 1/3 days. But the ancient peoples knew this and followed its motion from night to night as it slipped *eastward* among the stars. We, too, can easily verify this ourselves. No telescope is needed. The only essentials are sufficient interest and a few clear nights, preferably between new moon and full moon. We can easily see that between one night and the next, the moon moves easterly among the stars a very considerable distance. It is this fact that makes it rise and set about an hour later on each successive night. If we can see the moon when it is quite near some bright star, we can note its easterly motion with respect to the star, in an hour or two. Try it any of these nights and you will be surprised how easy and how fascinating it is. You will find that it moves eastward each hour a distance almost exactly equal to its diameter. In 27 1/3 days the moon moves clear around the sky and begins its journey over again.

"New" moon occurs when the moon is in the direction of the sun, or nearly so. When the moon is only a day or two old, we see only a thin crescent. The moon is a dark, dead, cold object, and gives out no light of itself, but is visible to us only because of the sunlight which it reflects to us. Now the sun is far beyond the moon, in fact, it is four hundred times as far away. Hence at new moon the illuminated part of the moon, which is, of course, always towards the sun, is turned away from us and we can see only a little of it, as a thin crescent, around the curved edge of the

moon. The new moon is always near the sun in direction, and therefore, if seen just after sunset, must appear in the west. Sometimes, people with good imaginations tell of being out in the mountains or down by the lake shore, and of being entranced by the beauty of the silver crescent of pale new moon stealing up from the eastern horizon! Never, never can this happen, and any man who tells this story and insists on its truth—well, he should be asked the name of his lady friend. It is surprising how the man in the moon affects men and women on whom his quizzical smile falls. By the end of a week after new moon, the moon is at first quarter and is seen as a half-circle in the south at sunset. A week later still the full moon will be rising over the eastern horizon as the sun is setting in the west. During the next week the moon moves on around to third quarter, and at the end of a month is back again to new moon in the direction of the sun. During this time, however, the sun has moved eastward a certain distance and it takes the moon a little over two days to catch up to him, thus making the time from new moon around again to new moon not 27 1/3 days, but 29½ days. This period of time is a "moonth" or, as we call it, a month. The month has been a natural division of time for ages past.

The moon is one of the seven heavenly bodies which the ancients observed to shift their positions among the stars. After these seven moving objects were named the days of the week, thus, for example, "Sunday", after the sun, and "Monday" after the moon.

You might be interested in the amount of light we receive from the full moon. Sometimes coarse print can be read by full moonlight. But how feeble is this light when compared with sunlight! The sun sends us 600 thousand times as much light as the full moon. Or, we may put it another way: if the whole sky could be filled with full moons, we should get only one-eighth as much light as we get from the sun. In spite of this, however, some people claim that the moon is more important than the sun, since the moon shines at night, when we need it, while the sun shines in the daytime when we don't.

The moon has long been considered by thousands of people to hold certain influences over our animal and vegetable life and our

weather. When the crescent is lying on its back some say the moon is holding the water and we are going to have dry weather; others say that the moon is soon going to pour out the water and we shall have wet weather. Evidently both cannot be right. It's a matter where "You pays your money and takes your choice". Many believe that the weather changes when the moon "changes". But the moon is changing all the time—no more at new moon or at first quarter or at full moon than at any other time in between. Again, the moon is in the same phase for all places all around the world at the same moment, and therefore, if the moon's phases control the weather, the whole world should experience the same sort of weather at any one time. But this is far from being the case. As a matter of fact, and quite contrary to widespread belief, we do not know the slightest connection between the moon and our weather. If the phases of the moon did affect the weather, and we knew what the connection was, we could, to that extent, predict the weather for hundreds of years ahead, since we know all about the moon's phases for centuries to come. Sometimes, when we have a big storm, we hear a so-called weather prophet say, "I knew we were going to have a storm, for the moon rose last night away round to the *north*-east, while the night before it rose away round to the *south*-east". May I say that while this may happen on two nights two weeks apart, it absolutely can *not* happen on two *successive* nights.

Then, too, hundreds of folk all around us plant their potatoes at new moon so they will grow rapidly as the moon waxes larger. And how many, many people through the country kill the hogs at new moon, so the fat will not shrivel up when the pork is fried. I know one man who declares this to be true, because, as he says, he has seen it. My best advice under such circumstances is to fry it in lux so it won't shrink. Again, I have heard that some farmers, in building a new fence, dig the post-holes at the right time of the moon, whatever that is, so the frost will not heave the posts out of the ground. Also, I have been told that if one always gets one's hair cut at the right phase of the moon, one will never be bald. It has long been a rather common belief that people's minds are often affected by the moon, and indeed, that is the origin of the words

"lunacy" and "lunatic", from the Latin word "l-u-n-a", which means the moon. Perhaps we should not be too dogmatic and state that there is absolutely no truth in any of these beliefs. It would be safer to say that, as far as we know at the present time, the moon does *not* affect the animal or vegetable life or the weather. However, we do know that it does affect the earth in a very real and important way, in that it raises the tides in our oceans and carries commerce in and out of many harbours that otherwise would not be navigable. One evening last summer John and Mary were strolling along the shore of Lake Erie while a beautiful full moon was rising out of the eastern end of the lake. Suddenly Mary stopped and said, "John, do you really think the moon away off there affects the tide?" "No, dear," replied John, "just the un-tied."

"But," some of you are saying, "what about the Man in the Moon?" On the surface of the moon we notice with the naked eye bright portions and dark areas. The dark regions are great level plains, and have been named "seas" because when Galileo with the first telescope, examined them, he thought they were great bodies of water like our oceans. But we know now that there is no water on the moon. We have, however, retained the name "seas" for these great level stretches. It is these seas which appear to many to give to the moon the appearance of a man's face, although a rather active imagination is required to obtain this effect. Some say they can see an old lady reading a book. Now anyone can very easily discern on the right half of the moon the figure of a crab, which, I think, is certainly very strong evidence that the figure cannot possibly be a *man*. The *lighter* portions of the moon are, in general, the *rougher* parts, abounding in mountains and thousands of craters. These rough areas are very, very rugged, resembling somewhat our Rocky Mountain region. The lunar mountains are, in many cases, very much higher than the highest peaks on the earth. The craters also far surpass any terrestrial craters. The largest crater on the earth is eight miles wide, while on the moon many craters are over 100 miles wide, and there is one whose diameter is 150 miles. The depth of the deepest craters is from two to five miles. Truly, if these vast depressions were caused by volcanic

explosions, the moon must have experienced some terrific blow-outs. Probably, however, they were not caused in this way, but we are not sure as to just how they were produced.

The moon's surface is never obscured by clouds or haze of any kind on the moon; we can look right down upon it, when there are no clouds in our own atmosphere. The moon is a very desolate place with no clouds, no rain or snow, and, in fact, no air. This would mean that no sound could be heard on the moon and, indeed, ordinary speech would be impossible. The moon is not massive enough to hold an atmosphere if it ever had one. The force of gravity on the moon is only one-sixth that of the earth; that is, if a man weighed 180 pounds *here* he would weigh only 30 pounds by the same spring scales on the moon. An athlete who could jump five feet high here, could, if transported to the moon, jump 30 feet high. Of course, no people constituted as we are, could live on the moon unless they carried with them a supply of oxygen. Probably the extreme ruggedness of the moon is due in part, at least, to the lack of an atmosphere with the consequent *absence* of all *erosion* by wind, water, snow or ice. This lack of atmosphere causes the moon, when it passes in front of a star, to cut off the star's light instantaneously. This "occultation" of a star, as it is called, is a very pretty sight when the star is a bright one, and when the moon is only a few days old, so that its *forward*, that is, its *eastern*, edge, is dark. As it moves up to the star, the latter seems to disappear suddenly out of a clear sky. We must not forget that the moon is a great ball, even though it sometimes appears as a part of a circle. The poet, Coleridge, in "The Ancient Mariner", speaks about "the hornéd moon with one bright star within the nether tip". Now Coleridge must have had most *un*usual eye-sight, or something else, to see a star in the moon's crescent, since the *nearest* star is far, far beyond the moon, in fact, just about 100 million times as far away, and the moon is a solid body a little over 2,000 miles through. We might add here that the distance is about 238 thousand miles, or a little over a quarter of a million miles.

Did you ever notice that the full moon always looks just the same? As it journeys around the earth month after month, and year after year, it always keeps the same face towards the earth,

and we never see the other side. This means that the moon rotates once on its axis in a month; that is, it has a day of four weeks instead of 24 hours—two weeks of daylight and two weeks of night. It is very strange, indeed, that the moon's period of rotation on its axis and its period of revolution around the earth should be *exactly* the *same*. With no atmosphere to ward off or absorb a portion of the sun's heat during the day or to prevent rapid radiation at night, the moon must get very hot during the long day and bitterly cold during the two weeks at night.

If we could live a month on the moon, we should have many strange experiences, some of which we have already noted. There is time now to mention only one more. If we were on the side of the moon towards the earth, the earth would remain in one position in the sky all the time, unless we changed our location on the moon. How strange this would be! Now the earth is about four times as wide as the moon, that is, its surface is about 16 times that of the moon. Hence, if we were on the moon, the earth would appear as a large object, 16 times as large as the moon appears from the earth. It would always remain fixed in one place, and would pass through phases from new earth through first quarter to full earth, and on around again to new earth. Moreover, during this time we should see the earth turning around every 24 hours on its axis, presenting a continuously changing view of green continent and blue ocean, varied now and then by vast areas of brilliantly white clouds. During half of the month we should be viewing the snow-cap over the north pole, while during the other half, we should see the Antarctic regions. Surely the Man in the Moon must have an interesting time watching the earth, his nearest heavenly neighbour!

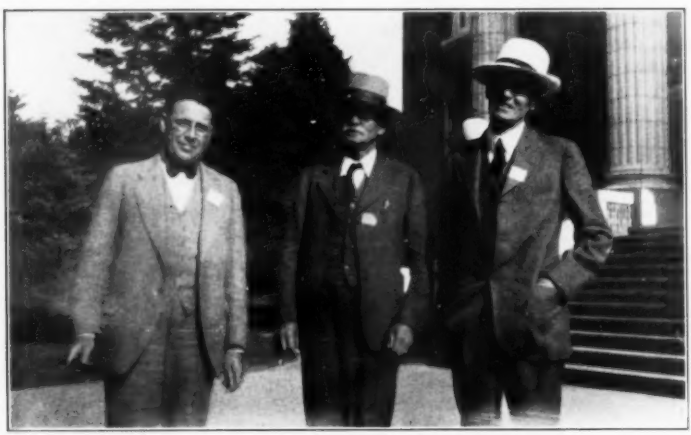
PLATE XXII

A. E. Douglass

University of Arizona, well-known for his researches on "tree rings".

*Journal of the Royal Astronomical Society of Canada*, 1930.

PLATE XXI



AT THE EUGENE MEETING

UPPER: (*Left*): W. F. Meyer, President of the A.S.P.; (*Right*): J. Murray Luck, Gen. Sec., A.A.A.S.

LOWER: (*From left*): M. L. Humason, C. E. St. John, W. S. Adams; all of the Mt. Wilson Observatory.

*Journal of the Royal Astronomical Society of Canada*, 1930.

# THE EUGENE MEETING OF THE A.A.A.S.

By W. E. Harper

With plates XXI, XXII

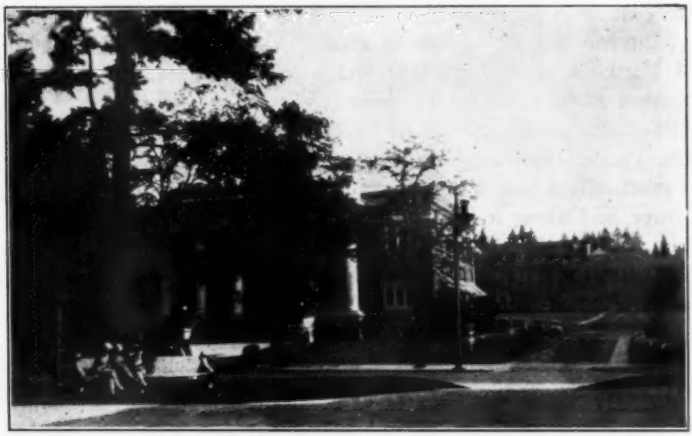
The fourteenth annual meeting of the Pacific Division of the American Association for the Advancement of Science and Associated Societies was held at the University of Oregon, Eugene, Oregon, from June 18-21, 1930.

Eugene is a city of about 20,000 population, 125 miles south of Portland, at the southern end of the Willamette valley. It appears to be ideal for a summer sojourn, as ocean breezes and well-shaded streets contribute to one's comfort in the hot season. The Pacific Highway, which passes through the heart of the city, is practically a paved street from Vancouver, B.C., to the Mexican border, and along it in both directions, at this season of the year, rolls a seemingly endless procession of cars. Tourists, as they enter this beautiful city, verdant with grass, avenued with trees and brightened with masses of beautiful *Caroline Testout* roses, are attracted, and pause to rest and enjoy some of its beauty.

Amid such congenial surroundings the members and interested visitors to the meeting came together to the number of about 450. Fifteen associated societies of entomologists, chemists, mathematicians, meteorologists, physicists, botanists, astronomers and whatnot, were represented in the gathering. Headquarters were established in the Administration Building of the University, while the various sectional meetings were held in suitable lecture rooms scattered about the campus. Quite a number of the members availed themselves of the facilities of the new dormitory for men. Here, with comfortable beds and good meals, one had every reason to be grateful for the solicitude shown for their comfort. Provision was also made for several excursions to neighbouring points of interest. The writer was unable to participate in these as they interfered with some of the sessions he wished to attend, while the extended trip on the closing Saturday was scheduled to return just

too late to make train connections. Those who went on that trip, however, report a very enjoyable and instructive outing.

The Association as a whole met on the opening afternoon to listen to a review, by four selected leaders, of the achievements of the year in science in America. Immediately following this the members adjourned to the Colonial Theatre, where, by courtesy of the manager and the General Electric Company, two sound films of exceptional interest to the gathered scientists were presented.



**Administration Building, University of Oregon, with Alumni Hall in background.**

One was on "Radioactive Rays", by C. W. Hewlett, and the other, "Arrangements of Atoms and Molecules in Crystals", by Sir William Bragg. The latter's voice was very natural as the writer remembered it from his interesting talks at the Toronto meeting of the British Association in 1924. At the conclusion of the showing of these films, members wended their way back to Alumni Hall, where President Hall of the University and Mrs. Hall, held a reception for the members and their friends. At such a time one makes many new acquaintances and has an opportunity also of informally discussing problems with those who have a common interest in them. A pleasant and instructive quarter of an hour was

spent here also, viewing under competent guides the Murray Warner collection of Oriental Art for which a splendid new building is nearly completed on the campus.

Two forenoon sessions were given over to the astronomical papers, of which there were 28 presented. A sentence summary only will be attempted of each at this time, as doubtless most of them will find their way into print in the near future.

Aitken's new general catalogue of double stars (A.D.S.), now in press, showed that some 7,500 to 8,000 new pairs had been discovered since Burnham's time, and even discarding about one-third of the number of wide doubles used in Burnham's list, the new catalogue will contain 17,181 entries.

Nicholson and (Miss) Sternberg reported that the solar activity is decreasing, being definitely less in 1929 than in 1928. While the past maximum has been of the rounded variety with fluctuations having a period of about 15 months, yet the real maximum may be set down as taking place early in 1927.

Hill gave the orbital elements of the spectroscopic binary 103 Tauri, which he had determined from 36 Victoria and 59 Mount Wilson spectrograms. Harper reported on four orbits of A-type spectroscopic binaries which he had recently determined, whose periods ranged from 1.5 to 4.2 days.

Neubauer at the Santiago station of the Lick observatory, had been taking spectra of stars fainter than magnitude 5.5 and radial velocity results for 354 are now available, 180 of which are of B-type. Pearce and Plaskett gave details of a catalogue of radial velocities of O to B5 stars, numbering 996 in all, which have been determined to date at all of the observatories in the world. Of this number 258 have been observed solely at the Lick observatory, while 458 is the similar number for Victoria. Slightly over fifty per cent. of the probable errors for the accepted mean velocity are less than $\pm 2.0$ km./sec.

Using the velocities for 680 of these stars, Pearce has made a new determination of the solar motion, galactic rotation and K term. The stars fainter than 5.5 magnitude of type O to B2 clearly demonstrate the rotation about a distant centre in galactic longitude 328°, while the brighter and supposedly nearer stars do not

show such a general rotation, but rather one about the centre of the local cluster.

Humason and Christie described the spectra of two F-type stars, showing bright lines. One was constant in velocity, the other a spectroscopic binary whose period is 18.58 days, but the orbital elements of which seemed to vary from time to time.

Considerable interest was centered around the new object found at the Lowell observatory and Slipher reported on its discovery and the early orbital computations. Whipple gave his own recent determinations of the orbit, utilizing the new data accruing from the discovery, some ten days previous to the meeting, of the object on Mount Wilson plates of 1919. The results of Nicholson and Mayall from the same data were almost identical with Whipple's, and the eccentricity of 0.256 so determined, coupled with the fact that Mount Wilson has found for it a spectrum more or less of solar type, should lessen the opposition to it being considered a planet.

From long exposure photographs with the 60-inch reflector on the planets Uranus and Saturn, Christie had concluded that no additional satellites of these planets existed which were brighter than 18.5 magnitude. Miss Hayford determined the orbit of comet 1930 d, and found it to resemble that of Daniel's comet of 1909. Menzel has studied the spectra of the outer planets in which marked absorption bands occur, and seems to feel that these are due to hydrogen, oxygen or water.

Moore reported on the success of the solar eclipse expedition to Camptonville on April 28th last. Photos of the flash spectrum were obtained as well as directed photos, the latter suggesting that the eclipse there was annular, not total. Observations by Jeffers from an aeroplane to photograph the moon's shadow on the ground were unsuccessful. Similar work attempted by Brackett with observers in two army aeroplanes at altitudes approximately 19,000 feet showed that the method was hopeful. Photo-electric determinations of the strength of the residual light at various points *across* the shadow yielded results confirmatory of the exact position of the shadow path.

The foregoing are abstracts of the papers presented at the first

forenoon session. At the second forenoon session the writer had the honour thrust upon him of being chairman. One would have thought that the chairman of the Programme Committee was ample honour but our American friends are noted for their over-generous treatment when we go south of the line. It so happens that being in the chair is not conducive to summarizing papers, but a few items of the second series of papers may be recalled.

Beals outlined a suggested classification of Wolf-Rayet stars which will run approximately parallel to the corresponding subdivisions for absorptions O's. In a new series of radial velocity observations of Y Cygni Redman obtains evidence for a rotation of the line of apsides in confirmation of earlier photometric work. Pictures were shown by Adams of the 50-foot interferometer recently completed at Mount Wilson. It is in the form of a cantilever bridge extending in an E-W direction across the north end of the polar axis and tests made on Betelgeuse and Arcturus give results in agreement with those obtained with the 20-foot. Continuing the experiments on ether drift with instrumental equipment whose sensitivity is 100 times as great as that used by Miller, Pease and his associates show that the effect Miller found could be due to errors in the instrument. St. John reviewed the evidence for the Einsteinian displacement of spectral lines. The observations of Adams and Moore, taken in conjunction with his own measures of solar wave-lengths would seem to indicate that the general theory of relativity must now be accepted. Joy finds that the period of the eclipsing variable U Sagittae is not constant. The addition of a sine term with a period of 6,085 days, improves matters. From a study of open star clusters, Trumpler finds that, contrary to accepted opinion, absorption of light takes place in our stellar system. Intergalactic space is, however, highly transparent. By counting the number of lines of each intensity in the solar spectrum, Babcock finds that the abundance increases smoothly as we proceed from high intensity to low. Wave-length determinations made in furnace and arc spectra for the stronger lines of the rare earths, have furnished King, at Mount Wilson, with additional data as to the presence of these lines in the solar spectrum. By using high dispersion spectra of bright stars, Sanford and Adams find a varia-

tion of radial velocity with excitation potential. Lines of the neutral atom of iron were used and the change of velocity with E.P. was determined. Spectra of the interesting 27-year period eclipsing variable Epsilon Aurigae were shown by Adams and Sanford. These were made with very high dispersion and showed the lines double in November, 1929, and February, 1930. It was another illustration of the value of having the best instrumental equipment to attack the problem. Much of Ludendorff's work with low dispersion must go by the board in view of these recent results.

While important researches are embodied in the papers so briefly referred to, the reading and discussion of which were of much value to those present, it might be considered by some that the joint meeting of mathematicians, physicists and astronomers on the Thursday afternoon was of even greater value. This was in the nature of a symposium on the subject, "The Red Shift in the Spectra of Distant Light Sources and its Physical Interpretation". Humason, of the Mount Wilson Observatory, detailed the observational evidence obtained of these great line shifts: Hubble, of the same observatory, correlated such apparent velocity displacements with the distances of the objects, while Tolman, of the California Institute of Technology, gave a mathematical discussion showing how such line shifts need not be considered as velocity displacements in the ordinary sense, but rather shifts explainable by the excessive radiations of these distant objects.

The beginning of such work may be traced back to the study of Cepheid variables in nebulae. Assuming that they are similar in luminosity to those of our own galactic system, it was possible to deduce the corresponding distances of the nebulae in which they were embedded. Thus Shapley obtained the distance of the Lesser Magellanic Cloud as 32,300 parsecs, or somewhat over 100,000 light years, while Hubble's determination for the Andromeda spiral placed it at nearly 900,000 light years. It was with difficulty that the Andromeda nebula could be resolved even with the 100-inch, consequently little hope was held out for the determination in this way of the distances of very faint nebulae, since they could never be resolved into individual stars. It was thus desirable to obtain some more indirect method, and while diminishing size mght be

taken as an index of increasing distance, a more rigorous criterion was desired. From a study of the nearer ones whose distances were known, a relationship was found by Hubble to exist between the velocity (invariably that of recession), and the distance, the latter increasing linearly with the velocity. To obtain more observational data, particularly with respect to the fainter nebulae, a programme of observation has been carried on at Mount Wilson for a couple of years, obtaining spectra of these. The results for 45 have now been secured, and were presented by Humason. The list as thrown on the screen showed velocities of recession from 650 km. per sec. to one for the nebulae Baade 24, for which, after an exposure of 67 hours, a spectrum was secured which, when measured, showed the amazing velocity of 11,500 km. per sec. All these high velocities fell on the extension of the straight line curve previously found to connect velocity and distance, and thus the correlation may be assumed to be established. It was Tolman's part to show mathematically how these displacements of spectral lines can be explained on theoretical grounds, which he did in a seemingly logical fashion, although the writer must confess his inability to follow him through all the mazes of extended formulae with which he was perfectly familiar. His final formula was a very simple one, and one which can be experimentally checked up, as doubtless it will be in the near future. Dr. Adams, who was in the chair, remarked how this was a new method to reach farther into the violet end of the spectrum, as such redward shifts correspond to over 100 angstroms. From conversation with other listeners, the writer learned he was not alone in his inability to follow the speaker, but all agreed it was not the fault of the presentation, which was brilliant. It was an added delight to know that Dr. Tolman was, after all, quite human like the rest of us, as in conversation with him, I learned of his fishing exploits on our own island.

The whole Association, as previously mentioned, met in general session on the first afternoon (Wednesday) to listen to a review of American Advances in Science as summarized by four selected leaders, two representing the life sciences, and two the physical sciences. Anderson of Mount Wilson, and Brode of Berkeley,

divided the latter topic, Anderson taking geology, seismology and astronomy. He stressed the part the University of Oregon is taking in the study of what is known as the John Day River region in Oregon, a district very similar to the Grand Canyon of Colorado, and which is one of the first regions in Western America to be studied intensely from a geological standpoint. In astronomy he instanced three items as outstanding, (1) Interstellar calcium as found by Plaskett and Pearce; (2) The new planet; (3) Red shift of lines. In regard to the last mentioned he was inclined to think that a common cause would be found to account for these excessive line shifts, and the rotation found by Van Maanen to exist for the spirals. Brode commented upon investigations in physics and chemistry in progress at Berkeley, where rare earth elements are being studied, at the University of Southern California, where the structure of crystals is under investigation, and at the University of California, where a study of spark discharges seems to indicate an increase in the widths of lines with time due to the Stark effect.

The popular meetings at night, for the public as well as the members, were well attended. The President of the Pacific Division, Dr. D. H. Campbell of Stanford University, gave the first one on "Origin of Land Plants", and traced the development from green algae to the more simple forms of land plants, and onward. On the second evening, Dr. Douglass of the University of Arizona, thrilled an audience that filled the Music Auditorium as he spoke on "Tales Told by Tree Rings". The chairman introduced him as an astronomer who had delved into archeology, using botany as his tool of exploration, and thus he was a living embodiment of scientific co-operation. Everyone knows that each year's growth of a tree is marked by a ring whose thickness varies with the rainfall and other meteorological conditions. Dr. Douglass has now a complete record back as far as 700 A.D., and it is so definite that figuratively "he who runs may read". By examining old timbers taken from the dwellings of the Hopi Indians who once inhabited Arizona, he was enabled by this record to assign the date of their construction some 350 years ago. Later these tribes were massacred or driven out by the Spaniards. His moving pictures of the passage of the years from 700 A.D. to the present, as illustrated by the

composite photograph, was intensely interesting, accompanied as it was by corroborative historical records of "lean" years and "fat" years for tree growth.

In this summary rather hurriedly prepared, the writer has tried to give lay readers of this JOURNAL some impressions of this meeting, as well as a popular account of the scientific achievements for the year as reported in his own particular field of astronomy. As those who attend such meetings know full well, it is not only the papers presented that are helpful, but the opportunity that is afforded for meeting with other workers, and informally discussing common problems. In both respects my colleague, Dr. C. S. Beals, and myself felt it was a great privilege to attend this Eugene meeting of 1930.

## "THE SIZE OF THE UNIVERSE"

(By Dr. L. Silberstein, Oxford University Press, 1930)

Review by A. Vibert Douglas

Those whose privilege it is to know the author of this book will read it with double pleasure—first, because of the substance of the book; and, secondly, because they will see the author himself in almost every page, hear his voice and behold his very gestures and play of expression. So vivid is this impression that it may well be said that the book is no mere impersonal scientific treatise, but a portrait of its gifted, versatile, enthusiastic, and impetuous author.

Should one, whose knowledge of the tensor calculus is insufficient to ensure a critical reading of much of the analytical portion of the book, attempt at all to review its contents? This, perhaps, is an open question. Yet I venture to do this very thing because I am sure that there are many with no more, and perhaps less, ability to handle the "precious tensorial material" with "well-nigh magical efficiency" (page 7) in laying the foundations for the great enterprise of world-building, who, nevertheless, like the writer, can appreciate much, if not all, of the significance of these efforts, and follow with interest the trend of thought of the great modern cosmologists.

After a most admirable and concise survey of tensors, projective space (considerations of the geometry of which elicit the adjectives, "marvellous, rich, and unspeakably beautiful"), Staudtian scale, spacetime, and curvature, the purpose of the book is clearly set forth on page 38:— "Contemplate our spacetime as a four-fold of *constant curvature* (K) . . . . . It is exactly the purpose of this book to find out whether there are reasons weighty enough to discriminate between $K \gtrless 0$, and to place the value of the world-curvature between certain numerical limits". This decision, we are told, must rest with mathematician, observing astronomer and experimenting physicist working in collaboration.

Fourteen pages dealing with metrics, curvature (Gaussian and

Riemannian), the conditions for constant curvature and finally Einstein's two "bridges" (the postulates of General Relativity), connecting the abstract world-geometry with physics, bring Part 1 to its conclusion.

Part 2 opens with Einstein's and de Sitter's attempts to find a tensor applicable to "spacetime at large"—the former involving the property of homogeneity without isotropy, the latter ensuring that "precious property" (page 67), namely, isotropy, and hence also homogeneity. Einstein's cosmology is then discussed with considerable detail, emphasis being laid upon certain artificial assumptions and difficulties which lead the author to reject this solution as entirely untenable and in contradiction to the observable properties of the actual world. — "With due respect to the founder of modern Relativity, this superstructure of his masterly theory is entirely indefensible" (page 84). Throughout the chapter, both in the lines and footnotes and between the lines, one can perceive the sharp keen points of the author's rapier-like criticisms and witticisms fairly scintillating in the sunshine of his own enjoyment of his task!

Part 3 is a devastating attack upon Dr. Hubble's conclusions drawn from his examination of 400 of the extra-galactic nebulae and his evaluation therefrom of the average density of space, which, by the aid of Einstein's formulae relating mass, density and radius of curvature of the Universe, leads to a size-estimate of Einstein's polar and antipodal space. Dr. Silberstein criticizes the legitimacy of drawing conclusions regarding 400 galaxies from data known accurately for only six, criticizes the analytical methods employed, criticizes the deductions, and criticizes Hubble's interpretation and application of "that great and valuable principle of Uniformity of Nature"—this last with a vigour and earnestness amounting almost to mystic fervour (page 91). After recording Hubble's estimate of the radius of the Einstein world as $2.7\times10^{10}$ parsecs, equivalent to a mass-total of $9\times10^{22}$ suns, and after quoting Hubble's statement that soon the great telescopes will enable observation of "an appreciable fraction of the Einstein Universe", the knock-out blow is delivered thus (page 99), "Unfortunately, however, and quite apart from the very weak support of Hubble's (density of space)

value, *no part* of Einstein's Universe can ever be observed, since this (cylindrical) Universe, leading to absurd consequences, cannot —in any reasonable sense of the word—be said to exist at all"

In concluding this chapter, an incidental remark is made that is worthy of due contemplation, namely, that while Einstein's relation for the radius of the world makes absolutely no contact with observable, determinable physical qualities, the radius of the electron is no better off in this respect at the present stage of physical theory.

One remark regarding the spirit of these pages seems called for. The cosmologist may be justified in levelling his criticisms at the handling and interpretation of observational material, but on his own admission (page 38), no progress can be made without the collaboration of the observing astronomer. Dr. Hubble's paper, the subject of this chapter, may warrant severe criticism, but there is no excuse for attempting to annihilate completely an astronomer whose contributions to knowledge regarding island galaxies merit the respect and gratitude of astronomers and cosmologists everywhere.

Passing now to Part 4, we find a careful discussion of the physical properties of de Sitter's isotropic spacetime, with the prediction of a shift of the spectral lines of distant stars towards the red end of the spectrum. Here is where the author's personal contribution to cosmological theory makes its appearance. By rejecting de Sitter's assumption that the light source is at rest relatively to the observer, our author develops certain interesting "laws of motion of a free test particle inserted in this spacetime" (page 111 et seq.). The conclusion arrived at is that "a universal scattering tendency . . . . . is by no means a characteristic feature of the isotropic spacetime . . . . . although restlessness of free particles is one." (Page 118.) Developing next the propagation of light or the minimal lines of this spacetime, a minimum parallax is found to exist having the value of the reciprocal of the curvature radius expressed in astronomical units. Following this a "centrifugal tendency is investigated leading to a unit of time named the *cosmic day* whose value depends only on the curvature radius and velocity of light.

Part 5 brings us to the author's main theme—the complete Doppler formula applicable to this isotropic spacetime unrestricted as regards the motion of the star relative to the observer. This formula involves (in addition to expected quantities) the curvature radius of spacetime and "two inexplorable *individual* star-constants."

Intent on obtaining an estimate of the all-important radius, the latter two constants are assumed to have random values and a statistical treatment is adopted which leads to a relation applicable to all available data for both distances and observed radial velocities of distant objects. The information derivable from the globular clusters and Magellanic clouds gives (page 143) $R=3\times10^7$ parsecs approximately, and a further estimate follows based on 38 spirals in addition to the clusters ($4\times10^8$ parsecs).

Subsequent paragraphs deal with the critical radius of a star or a galaxy, and the criteria for stability which incidentally are not fulfilled in the case of our own galaxy.

Those who are already familiar with Dr. Silberstein's Theory of Relativity (2nd Edn.), will find their chief interest in the present book in the nine Miscellaneous Notes which occupy the last 34 pages. A vigorous and spirited reply is made to certain criticisms of the author's views by Professor Weyl in 1924. In another note the radiant energy traversing inter-stellar and inter-galactic space is taken into account and a modified Doppler formula involving the curvature radius is obtained.

Three further estimates of the curvature radius are made from sets of data not previously utilized:—24 Cepheids yield the value $1.46\times10^8$ parsecs; 35 O– stars give $1.58\times10^8$ parsecs; 459 stars from Young and Harper's 1924 memoir lead to a value in very fair accord with the previous two, $1.96\times10^8$ parsecs. The weighted mean of these is $1.91\times10^8$ parsecs, and "being based in all upon 518 stars, can be accepted with confidence as the size of the curvature radius of spacetime" (page 211).

This book deserves to be called a cosmological detective story, and few who penetrate any distance into it will lay it aside unfinished. Whether they will feel at the conclusion that the mystery has been fully solved is quite another question. A few of the elect will undoubtedly shake their heads with dissatisfaction, even though

they can themselves offer no alternative solution. Many, however, will acclaim it as a valiant and valuable attempt to solve a great mystery—the true nature of spacetime. But the amateur detectives who hail this as a true solution will do well to take heed of the warning issued by the author himself (page 126), that the significance of a *model* must not be exaggerated. Another great cosmological detective has gone further and warned us to regard all such structures as *maps* not as models!

Some astronomers will feel that two million parsecs is a surprisingly small radius and will rebel against accepting it in spite of the high correlations exhibited by the observational material. Quite recently Lemaitre and Eddington have independently carried out investigations which point to the present state of our universe being a transitional one between the Einstein and the de Sitter states. The latter is the ultimate state towards which the whole (physical) creation moves, by a process of expansion accompanied by degradation and dissipation of energy. *If* this be so, then perhaps it is not to be expected that a relation, applicable to the final state and evaluated by means of observations of the stars during the present intermediate state, will lead to the correct value of the radius at the present time. If the expansion be going on at the rate suggested by Eddington (radius doubling within geological time) the marvel is that any correlations of the kind found by Silberstein should exist at all.

Dr. Silberstein's interpretation of the de Sitter map reveals certain remarkable properties and relationships—what their true significance may be it is impossible to say, but that they have *some* significance can scarcely be doubted.

McGill University,
Montreal, P.Q.

# THE SUN

## A CONCISE SUMMARY OF INTERESTING ITEMS FOR THE AMATEUR

By W. G. Colgrove

*Name*—Most ancient peoples worshipped the sun and thus a variety of names have been given to it. Among the Egyptians it had three names:—Horus at dawn, Amen-Ra at noon, and Osiris at its setting. Among the Babylonians its name was Bel, later Marduk, and still later Shamash, with two others, Ninib in the spring and the morning, Nergal at noon and in the summertime. The Greeks called it Helios, the all-seeing and hearing one. The Romans gave it the names, Sol, the lone one, and Phoebus Apollo, the brilliant one. The Incas of Peru called themselves the children of the sun.

*Myth*—Phoebus Apollo was god of the sun as his sister Diana was goddess of the moon. He was the son of Jupiter and Latona and was supposed to foster archery, music and prophecy.

*Symbol*—⊙A circle with its centre, probably representing one of Apollo's sun-chariot wheels, or the sun in the centre of a planetary orbit, or a shield with its centre point.

*Sound*—In the music of the spheres the sun was supposed to be the mighty organ which unified the sounds of the planets.

*Colour*—Its colour is usually yellowish but varies from pale yellow to blood red according to its position in the sky as seen through our ever-changing atmosphere.

*Markings*—The entire surface is enveloped in gaseous vapors which are constantly moving about in turbulent fashion. On closer examination one sees the so-called "rice grain" texture from which arise the white torch-like faculae and the waving flames called flocculi. Here, too, we see sometimes the much-studied spots and the towering prominences of luminous gas.

*Stellar Magnitude*—Since the sun is so near to us compared with the other stars its magnitude is very high, about −26.5. Sirius, the brightest star in the northern sky, is −1.6, a difference of about 25 magnitudes, but in reality Sirius is about 26 times as brilliant as the sun, as seen at the same distance.

*Angular Diameter*—32′ 4″ with a parallax of 8″.8. This is almost the same as the apparent mean diameter of the moon so that they seem to be about the same size. But we must remember that the sun is some 93,000,000 miles away from us while the moon is only about 239,000 miles distant.

*Linear Diameter*—About 865,000 miles or some 400 times the actual diameter of the moon and 109 times the diameter of the earth. This makes its circumference in the neighborhood of 2,720,000 miles at the equator.

*Area of Surface*—About 2,350,000,000,000 square miles. We should keep in mind the fact that the sun's surface is not solid but gaseous.

*Volume*—In terms of the earth's volume as a unit, we find the sun to be about 1,300,000 times as great.

*Mass*—Again, in terms of the earth's mass as a unit, the sun is found to be some 333,400 times as heavy. One does not need to be urged to believe that the sun possesses and projects inconceivable power.

*Density*—Average 1.39 that of water, 1,000 times as dense as air, about as dense as soft coal, or about 1/4 the average density of the earth. This low density is related to the extreme temperature of the sun.

*Surface Gravity*—About 27.6 times that of the earth, so that a person weighing 110 pounds here would weigh over a ton and a half on the sun. His frame would be unable to support such a load and he would be crushed.

*Velocity of Escape*—384 miles per sec. This, of course, is due to the enormous mass and the consequent force of gravity. It would be very difficult for anything to tear itself away from such a grip.

*Period of Rotation*—At the equator, 24.6 days; at latitude 30°, 26.5 days; at lat. 45°, 27.5 days, and at lat. 80°, 33.3 days. This is, of course, determined by the motion of the spots and other markings, and by the spectroscope.

*Velocity of Rotation*—The sun rotates on its axis in the same direction as the planets. At the equator it is about 4,450 miles per hour, while at latitudes farther north or south the speed gradually decreases.

*Magnetism*—This is said to be characteristic of all rotating

bodies. It is not the same as gravitation, which is universal, but is localized in each individual body. The amount of the sun's magnetic power is enormous and we know that often it affects conditions on the earth, especially at and during the maxima of sun spots. The magnetic poles of the sun are, like the earth's, situated near but not at its axial poles.

*Direction of Axis*—The celestial point toward which the sun's north pole is directed is at R.A. 18 h. 44 m. and Dec. +64°. Its south pole points, of course, in the opposite direction.

*Inclination of Equator to Orbit*—7°15′. This causes the north pole to lean toward the earth in September and away from it in March; in other words, the sun's equator arches upward in the spring and downward in fall, while in the summer and winter seasons it assumes a horizontal position. On this account many powerful sunspots shoot their magnetic energy into space during the spring and fall, while in the summer and winter they aim more directly at us.

*Oblateness*—There is almost no polar flattening, the rotation being only about four times that of the earth. One would naturally think that the outer layers of the sun's surface, being so attenuated, would withdraw from the poles and form an equatorial bulge, but the powerful gravitational attraction probably prevents it.

*Distance from Earth*—On January 3, 1930, Perihelion 91,347,000 miles; mean, 92,897,500 miles; Aphelion, July 2, 94,448,000 miles.

*Temperature*—The average temperature at the surface is about 6000°C. or 10,800°F. The total heat emitted in 2 hours and 40 minutes could melt a sphere of ice as large as the earth. The interior is, of course, much hotter and has been estimated at 18,000,000°C. Some interesting theories have been formulated to account for the evolution and maintenance of this vast energy:—

1. Combustion, the burning up of the material of the sun, but this is no longer considered.

2. Contraction, due to gravitational force, but this also has been discarded as inadequate.

3. Meteoric showers, a constant rain of material from outer space; but this has been thought insufficient.

4. Cooling down, but most physicists declare there is no adequate evidence of such condition.

5. Disintegration of radium, but on further examination it has been discovered that radium loses half in about 1,600 years, which is too rapid.

6. Disintegration of uranium. This appears to be a more plausible solution, since uranium takes 3,000,000 times as long. It is still a burning question among solar physicists.

*Radiation*—Radiant energy is propagated by waves of different lengths for different colours. Waves about 1/40,000 of an inch in length produce red, those of 1/50,000 yellow, and those of 1/70,000 violet. Slower vibrations give warmth while faster ones produce what has been called dark light or the invisible ultra violet. In the case of ordinary yellow light enough waves are produced in one second to reach 186,000 miles. This is the commonly accepted speed of light.

The total radiant energy emitted by the sun is about 460 sextillion horsepower, of which the earth, with a diameter of about 8,000 miles, receives 1/2,200,000,000 or 230,000,000,000,000 h.p., while all the other members of the solar system intercept only about ten times as much. The vast remainder, then, seems to be wasted in space.

The solar constant of radiation is 1.94 calories per minute on each square centimeter of surface exposed to the sun. There is a small variation of from 5 to 6 per cent., but it is not enough to affect the earth appreciably.

*Proper Motion*—The sun, like the other stars, has a motion of its own in space, and it, together with the planets and other members of the solar system, is moving in a vast orbit toward the first magnitude star Vega some 27 light years away. To complete this enormous revolution will require untold centuries. At present we are travelling at a velocity of 12.6 miles per second or 400,000,000 miles a year, while Vega, with a diameter four times the sun and a brilliancy 53 times as great, is approaching us at 270,000,000 miles a year, so that in about 1,110,450 years we shall meet and pass only to continue on our way in space. We may never return.

*Age and Future*—We venture here on speculative ground. The less we say the better, and yet when we consider the laws of nature that man has discovered, together with their mathematical precision, we are almost driven to the conclusion that some time some-

where in space our system will meet a large star like Vega and be completely disrupted. Such a meeting is possible, but when?

*Special Features*—Under "Markings" we noted some of these, but now let us consider them in more detail.

1. *The Corona*—This soft pearly envelope of light surrounds the sun on all sides and stretches out into space between 300,000 and 3,000,000 miles while some of its streamers reach beyond 5,000,000 miles. The corona is highly attentuated and offers almost no resistance to an approaching comet. Its structure is radial rather than lateral like ours and is supposed to be composed of widely scattered dust, small liquid globules and gases, with an average density of one dust particle to every 14 cubic yards. It is visible during total solar eclipses only.

2. *The Chromosphere*—This is the "colour sphere" and is another layer of gas lying just beneath the corona with a thickness of between 5,000 and 10,000 miles. At total eclipse it appears as a brilliant reddish fringe from whose surface rise the fiery prominences. Some are called quiescent and take the form of enormous tree-shaped slow-moving bodies of glowing gas in which, with the aid of the spectroscope, one can distinguish hydrogen, helium and calcium in abundance; others, called eruptive, appear like giant fountains of fast-moving flame with a spectrum of iron, titanium, barium and sodium and with a rapid radial motion that sometimes stretches them into space more than a quarter of a million miles. Prominences usually occur at sun-spots and shoot out at 100 to 200 miles per second.

3. *The Reversing Layer*—This is an absorption medium which lies directly below the chromosphere and is also a blanket of gas between 500 and 1,000 miles thick. It gets its name from the fact that in the sun's spectrum one discovers a series of dark lines in the place of the usual bright ones, evidently due to the presence of cooler gases in this layer.

4. *The Photosphere*—This is the visible surface, which on careful study is found to be composed of the so-called "rice-grain" texture, a name which applies to appearance rather than to nature or actual size. These granules are really between 500 and 600 miles across, and, on closer observation, prove to be made up of smaller units about 100 miles in diameter. Nearly 3/4 of the sun's light comes

from these very numerous brilliant areas while the spaces between are duller in appearance and are probably composed of denser gases at lower levels. This whole mottled surface with its spots and their attendant faculae and flocculi is the photosphere or surface of solar radiation, but the energy for its production and projection rises from the inner depths where inconceivable and varying temperatures and pressures keep the great sphere in constant agitation.

5. *The Spots*—These are the most conspicuous markings. In appearance a typical sunspot looks like a black-fringed hole in the surface. They appear singly and in groups, some being quite irregular. They vary in size from those just visible, to great bellowing furnaces more than 200,000 miles across. The dark tone of the spots is only a lesser degree of brightness as compared with the glowing photosphere around them. Near and above the spots one often sees great flickering torches of lighter-coloured gas called faculae as well as other similar waving gaseous formations called flocculi. The spots distribute themselves irregularly a short distance on each side of the sun's equator from latitude 6° to latitude 35°. Their number increases and decreases in a period of from 7 to 16 years with an average maximum of about 11 years. At maximum the spots are from 14 to 45 times more numerous than at minimum. Many spots have a slow drift in latitude and longitude as well as violent internal movements which sometimes divide them into pairs or groups. Some continue for months and are seen to return with the rotation of the sun, while others vanish in a few days or even hours. In all spots there are magnetic fields due to the vortical motions of particles carrying electric charges; indeed, the whole sun is a huge magnet with poles not far from its axial poles. There is no doubt that this energy causes atmospheric changes, thus affecting our weather conditions. . Interesting graphs are now obtainable which show the correspondence of sunspots, prominences, magnetic storms, aurora, vegetation, bird migration, quality of crops, prices and even stock market quotations.

Strathroy, Ont.

# WRINKLES IN THE ART OF TELESCOPE MAKING

By E. I. Gale*

We have just finished the construction of a six-inch reflecting telescope, including pier and equatorial mounting, at the Port Perry High School. A number of boys under my direction began this project last January. Two discs of ordinary plate glass six inches in diameter and ¾-inch thick were secured. One of these discs was concaved by the well-known "three-motion" stroke, using various grades of carborundum between it and the other disc, which served as a "tool".

We mastered the intricate grinding stroke so readily that, in the flush of our first victory, we felt we were already veterans in the fine art of mirror grinding. This flattering hallucination, however, was soon to be rudely shattered, for under Foucault's eagle-eyed knife-edge test we made the disquieting discovery that in our youthful zeal we had gouged out a fine healthy hyperbola.

We wrestled with this stubborn figure for nearly two months, during all our spare moments, and in spite of honest trials of various remedies prescribed in "Amateur Telescope Making", our mirror through sheer cussedness continued to get steadily worse and worse.

We should have gracefully gone back to the beginning at this point and concaved the remaining plane surface on the back of the mirror, but before resorting to this final expedient were anxious to try an experiment. Accordingly, we chipped the pitch off the tool and gave the mirror a long spell of abrasion with No. 6 grit and alcohol, using the "short" stroke recommended for correcting an hyperbola on the pitch lap. This proved entirely successful in overcoming the difficulty.

A brief account of our testing apparatus might be of interest. A piece of hollow curtain rod six inches long and 5/8-in. in diameter with a pin hole opposite the flame of a vapo-cresolene lamp served

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as the artificial star. The arrangement of the apparatus is shown in Fig. 1. The lamp is mounted on a retort stand so as to be easily adjusted up and down. Beside this stand on a solid work-bench a smooth board was arranged to slide in a fore-and-aft direction in a pair of guides. This board was moved by the rearward projection of a small mechanic's vice (seen in the foreground), and held

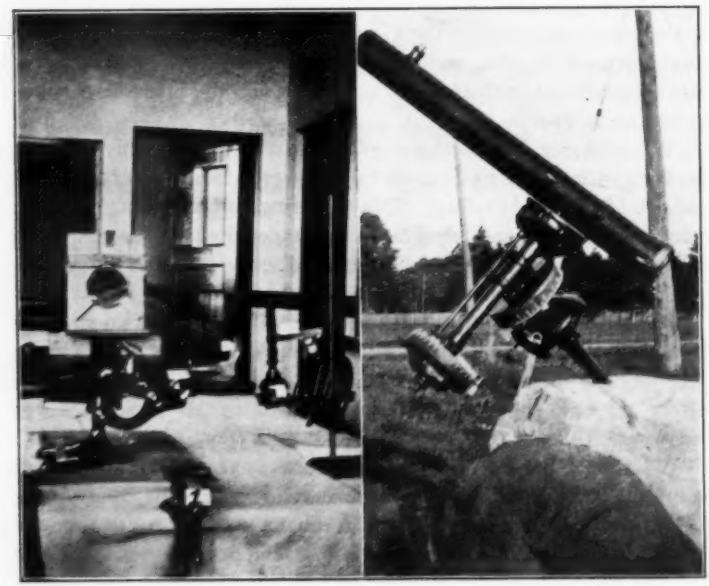

Fig. 1.—Arrangement for Testing.

Fig. 4.—The Completed Telescope.

in contact with the same by means of a spring. One turn of the vice handle was found to move the board through 1/10 in. On the top of the board an ordinary high power microscope was mounted with its barrel swung backward into the horizontal position. The eye-piece was replaced by a wooden plug carrying a safety razor blade. The vice moved the whole knife edge system parallel to the axis of the mirror, while the slow motion screw beside the barrel of the microscope enabled the operator to cut the knife into

the reflected beam from the mirror with great steadiness and precision.

We stopped figuring as soon as we got a reasonably regular figure on the knife edge and as soon as the outer zone of the mirror was one turn of the vice handle farther from the vertex than the central zone. By calculation this was about right for our paraboloid of revolution. We found this simply arranged testing machine of very great convenience while working in the dark room as the differences in curvature between the centre and the edge of the

Fig. 2.—Mirror in its Cell.

mirror could instantly be ascertained by merely counting the number of revolutions of the vice handle required to get from exact focus at one position to the other.

The Brashear method was used in silvering the mirror and was thoroughly successful on the second attempt. We found a burette of great value in adding the requisite amount of ammonium hydroxide to solution A.

The mirror cell was constructed of the discarded brake drum from the transmission of an old model-T Ford. Fig. 2 shows the drum with a crack in its rim at 5. This defect proved an advantage, for after the stub was cut away with a hack saw an adjustable

clamp was bridged across the crack. There was enough resilience to the band itself to enable the mirror to drop down into the machined inner cavity, and then have the six internal projections gently but firmly tightened on its circumference by means of the horizontal bolt shown under 5.

Thick lugs (6) were then rivetted to the steel tube through which three hexagonal-headed bolts were passed. These bolts entered the already threaded holes in the edge of the brake drum. The drum was then screwed up into positive contact with the lugs, which were rather thick so as to permit filing until the mirror was exactly at right angles to the telescope tube. This collimation was effected by placing the pin-hole lamp with its pin-hole on the axis of the telescope tube at the centre of curvature of the mirror. We made the discovery here that it is actually possible with a silvered mirror to bring the image of the pin-hole into exact coincidence with the pin-hole itself by altering the seating of the mirror cell. The advantage of this mounting resides in the fact that it is always possible to put the mirror back on the tube in its correct relation to the little diagonal reflector.

The polar axis housing consists of an entire rear axle housing obtained from an old Overland car with the exception of a part of the housing from one end to a point near the first bearing in the differential, which was cut away with the hack saw. The entire equatorial system is shown in Fig. 3, just before assembling. The axles and all the gearing except the crown gear were removed. This latter gear is attached to a cage which forms the supporting frame for the "spider" gears and the inner bearings of the rear axle. It is rotatable on roller bearings, end play being taken care of by adjustable thrust bearings. This whole system was of such sturdy construction that we decided to use it for the polar axis instead of the conventional solid shafting, especially since the openings in which the axle pinions turned were of just the right diameter to form a driving fit for a short piece of 1¾-in. piping which was threaded at the end projecting out of the differential housing.

A galvanized tee was now obtained to engage this pipe. This tee is clearly shown in Fig. 3 and carries around its stem the hour circle. Holes were drilled and tapped in each arm of the tee 120

degrees apart and provided with set screws. A half rear axle housing from an old Chevrolet was now obtained. The differential bell was taken off, the other part slipped through the tee, and the half differential housing rivetted on again. This forms a splendid declination axis as the hub and brake-drum form both a counterpoise and declination setting circle. The brake-rod mechanism was altered slightly to be made adjustable by means of a wing nut for clamping the telescope at any declination angle. On the opposite end an iron cradle was bolted to receive the telescope tube. This

Fig. 3.—The Equatorial System before assembling.

cradle supports two clamping bands which are conveniently held in position by thumb nuts, so that the tube can be attached or removed in a few seconds.

The telescope is shown completely assembled in Fig. 4. Its pier is cast in concrete around a big glacial float. Care was taken to insert a wooden plug in the bottom of the polar axis before the cement was poured. This plug was afterwards driven out and the hole can be used for future checking up on parallelism with the earth's axis. It also provides the necessary drainage from the weather. The instrument appears to have very good definition and already we have had a great deal of pleasure making observations with it.

## REVIEW OF PUBLICATIONS

*Heaven and Earth: a Modern Astronomy,* by Oswald Thomas, formerly chief of the Urania Observatory, Vienna. 231 pages, 5½ × 8 in. N.Y., Norton, 1930. Price, $2.75.

The author of this book was for some years in charge of a public observatory and interesting incidents in his experience are continually referred to. He also learned that questions relating to great speculative problems are the ones oftenest asked by the public, and considerable space is given to such. The last three chapters discuss the evolution of the stars, the genesis of the earth and the end of the universe; while other questions of whence and whither frequently occur.

The book was originally in a foreign language, but that is no objection, rather the reverse, since the translation reads very freely and there are references to foreign workers not generally known.

There are twenty-eight illustrations, all of the diagrammatic type,—no spectacular photographs such as are generally seen in a modern work on astronomy. The first chapter contains rather too many technical terms without adequate explanation. There are some statements which the present writer had never seen before. One refers to the origin of the world "colure". It is stated that the solstitial colure is so called, "for it means 'tail-cutter', because on the old star maps this line just cuts off the tail of the Great Bear."

There are several slight mistakes, such as "John and Adam" (p. 107) for St. John and Adams, which will be easily corrected on a second printing; but some statements appear to be incorrect. Referring to the dwellers on the moon, it is stated that "the Selenites perceive our earth always at the same point of the heavens" (p. 53). Again it is stated, "when a ray of light of any kind passes through a glass prism . . . . . it appears as a band of the colours of the rainbow; at the same time, this band is crossed by dark lines

and streaks, the so-called Fraunhofer lines". (p. 46). Of course, this is not true of all kinds of light.

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*La Planète Mars*, 1659-1929, par E.-M. Antoniadi, Astronome attaché à l'Observatoire de Meudon. 240 pages, 9 × 11 in., with 150 figures in the text and 10 plates. Paris: Hermann, 1930. Price (in paper) 80 frs.

Mr. Antoniadi is well known as an assiduous observer and an accomplished draughtsman. He began the study of Mars in 1888 on Princes Is. (Sea of Marmora) with a 3-inch refractor. Since then he has used instruments of various kinds and sizes, but his chief work has been done with the 83-cm. refractor at Meudon since 1909. Mr. Antoniadi was director of the British Astronomical Association section on Mars, 1896-1917, and is to be credited with the memoirs presented by the section during that time. In the second volume of Flammarion's great treasury of Martian knowledge, Antoniadi's researches have a prominent place.

The present volume, which is produced in excellent style, consists of two parts. Part I (pp. 3-59) is a general treatise on the planet. There are nine chapters and in them are discussions on the planet in antiquity, instruments and stations (including the comparative values of large and small apertures), astronomical and physical elements of Mars, the surface of the planet, the canals (which are declared to be illusions), snow-caps and seasonal changes, the atmosphere of Mars, conditions of habitability, and the phenomena of the two satellites of Mars.

Part II (pp. 61-224), contains a detailed analysis of all the recorded observations on Mars since the first crude sketch by Huygens in 1659. Full references are given to the publications consulted. The various topographical features of the planet are minutely discussed, and are illustrated with fine drawings.

There is a full index of 15 pages, which allows one to locate at once in the body of the book any information desired. The 10 plates at the end of the work are beautifully drawn and perfectly reproduced.

To the serious student of Mars this work is simply indispensable. It reflects great credit on the author and the publisher.

C. A. Chant

## NEWS AND COMMENTS

The degree of doctor of laws has been conferred by the University of Indiana on Dr. V. M. Slipher and Dr. C. O. Lampland of the Lowell Observatory, at Flagstaff, Arizona. (*Science*).

Professor A. S. Eddington delivered the Halley Lecture at Oxford University on May 30, taking for his subject "The Rotation of the Galaxy".

Dr. J. S. Plaskett has returned to Victoria after his trip through the United States and to England, during which he received the Rumford medal and the medal of the Royal Astronomical Society, and delivered many addresses, especially on the rotation of the galaxy and interstellar matter.

At the Paris Observatory, M. Fayet, director of the Nice Observatory, and M. Lambert, associate astronomer at Paris, have been appointed astronomers to succeed the late M. Fatou, and M. Hamy, who recently retired. (*Science*).

Astronomers the world over will say "Hear, Hear" to the following splendid tribute paid by the regents of the University of California, to President W. W. Campbell on his retirement from office on July 1: "On the eve of the retirement of President William Wallace Campbell, after nearly forty years of distinguished service to the University of California, the regents hereby record their appreciation of a great scholar, an outstanding administrator and an inspiring character. After a long and notable career as astronomer and director of Lick Observatory, Dr. Campbell came to the presidency at a time of many and difficult problems. Already eminent in the world of intellect and of knowledge, his high ideals, fine spirit, clear vision, decisive judgment and administrative efficiency as an executive have left a permanent record of achievement in the progress of the institution over which he presides. In the midst of complex external problems and great material development, he has never lost sight of the main purposes of a university: the

advancement of teaching and learning and the increase of usefulness to its students and to the state. With regret that the time of official retirement has arrived, and with the affectionate hope of many years of happiness and usefulness, the regents tender this tribute of acknowledgement."

At the recent convocation of the University of California, the degree of Ph.D. was conferred on J. A. Pearce, of the Dominion Astrophysical Observatory, Victoria, B.C.

From *Science* we learn of further details of the U.S. Naval Observatory's expedition, to observe the total eclipse of the sun on October 21, to Niuafou. The expedition will leave Washington on July 19 to sail from San Francisco on July 31 on the steamer *Sierra*, arriving at Tutuila, Samoa, on August 13. Niuafou is a very small volcanic island about 300 miles west southwest of Tutuila. Primitive conditions prevail on it and only two white men and 1,100 natives live there. Commander C. H. J. Keppler is in administrative charge; Lieutenant H. C. Kellers will be medical officer and in charge of meteorological observations; Professor S. A. Mitchell, director of the Leander McCormick Observatory at the University of Virginia, will conduct spectrographic work, with Kempton Adams as assistant; Professor Ross W. Marriott, Swarthmore College astronomer, will carry out coronal photography with a 63-foot camera and make observations to test the Einstein effect, having Dr. Weld Arnold as assistant; Dr. J. J. Johnson, of the California Institute of Technology, will make photometric observations; B. P. Sharpless, junior astronomer at the Naval Observatory, will do coronal photography with a 15-foot camera and other smaller ones; while Dr. T. A. Jaggar, Jr., of the Volcanic Observatory at Hawaii, will study volcanic and seismic conditions on Niuafou Island. About 115 cases of instruments and much lumber will be taken to construct the cameras, etc.

*REDeL*

# NOTES AND QUERIES

**Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.**

## A Daylight Meteor

Mr. R. N. Johns, of Oshawa, Ont., reports that at a picnic at Hampton Park on June 25 at 3.30 p.m., in bright sunshine, three ladies saw what looked like a silver ball about the size of an orange as it appeared almost above their heads, and then travelled towards the southern part of the sky. The fact that it was seen at such a time indicates that it must have been brilliant. No further reports have come in.

## The 2000th Anniversary of Virgil's Birth

At the meeting of the Royal Society of Canada in Ottawa in May last, Prof. N. W. DeWitt, of Victoria College, University of Toronto, presented a paper on the above subject, and in it remarked that 1931 was more accurately the year for the celebration. Dr. Pio Emanuelli, of the Vatican Observatory, has published a paper in *Rivista di Fisiça, Matematica e Scienzi Naturali,* (April, 1930) in which he reaches the same conclusion. He states that Virgil was born in B.C. 70, which is the same as −69 of our era, and 2000 − 69 = 1931.

## Another 6-inch Reflector

I am pleased to present herewith a photograph of a 6-inch reflector made by Mr. Stephen Stoot, of St. Hyacinthe, Que. Mr. Stoot is an employee of the well-known firm of Casavant Frères, builders of pipe organs. This instrument may also be credited to the book, "Amateur Telescope Making", published by *Scientific American.*

Mr. Stoot describes his mounting thus:

"A block of concrete two feet square at the base, tapering to

ten inches square at the top, and four feet high, has been sunk so that its top is level with the ground. Embedded down through the centre of this block is a three-inch iron shaft with an iron flange at the top seven inches in diameter and three quarters of an inch

Mr. Stephen Stoot with his six-inch Reflector.

in thickness. This forms the base for my mount. The whole outfit might be described as the Irishman once defined a certain article, viz:— 'a portable fixture', because I can take my telescope indoors at any time. When the upper part of the mount and telescope are removed, a triangular cell measuring 7¼ inches on each side, and 2 inches deep is left on the top of the pillar. A corresponding solid triangle at the base of the upper part of the mount

fits exactly in this cell, and three 3/8-inch brass pins are pushed through to hold the whole mount solid.

The telescope tube is a portion of a 6½-inch organ pipe of hard rolled zinc No. 16 gauge, and is very easily revolved in its cradle of hard wood. The other parts of the mount consist of pipe fittings, and two worm drive gears from an old type gramophone. Since the photograph was taken, I have added four more gear wheels to the worm drive of the polar axis, and thereby I get a slow motion in the ratio of about 1,000 to 1."

## The Planet Pluto

Two more preliminary orbits have been announced. The planet was found on four plates taken at Mount Wilson, Dec. 28, 29, 30, 1919; and from these positions, together with observations in 1930, Nicholson and Mayall, of Mount Wilson, computed an orbit.

From the Dec. 29th observation above, an observation at Uccle, Jan. 27, 1927, and an observation on May 24, 1930, Bower and Whipple, of Berkeley, also computed an orbit. The two orbits are given herewith:—

| | Mt. Wilson | Berkeley |
|---|---|---|
| $T$ | 1988 June 5.5 | 1989 Feb. 27.473 |
| $\omega$ | 111°46′ | 113° 8′26″.1 |
| $\Omega$ | 109°22′ | 109°21′36″.9 |
| $i$ | 17°9′ | 17° 8′57″.0 |
| $q$ | 29.6 | 29.253741 |
| $e$ | 0.2575 | 0.253741 |
| $P$ | 251.80 yrs. | 249.1661 yrs. |

## An Observatory in the Panama Canal Zone

Through the efforts of the Canal Zone Astronomical Society, with the assistance of the Canal Administration, an observatory has recently been erected at Miraflores. It contains a 5-inch equatorial telescope secured by the Panama Canal from the U.S. Navy. The building has concrete walls 14 feet in diameter, surmounted by a revolving steel dome. The observatory will be used for the instruction of the students of the Canal Zone high schools, and for Canal employees interested in the subject of astronomy.

C.A.C.

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